steam boilers

Berry Safety Boiler

BUILT BY

ROBERT WETHERILL & CO.

Engineers and Machinists

CHESTER, - - PENNA.

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THE

BERRY SAFETY BOILER

brings the practice of modern

BOILER CONSTRUCTION

"UP TO DATE,"

and places the Steam Generator on the same plane of excellence, convenience and efficiency as the modern compound and triple expansion engines, giving exactly the kind of steam they require, safely, regularly and cheaply.

We call the attention of constructing engineers and steam users to the following claims, all of

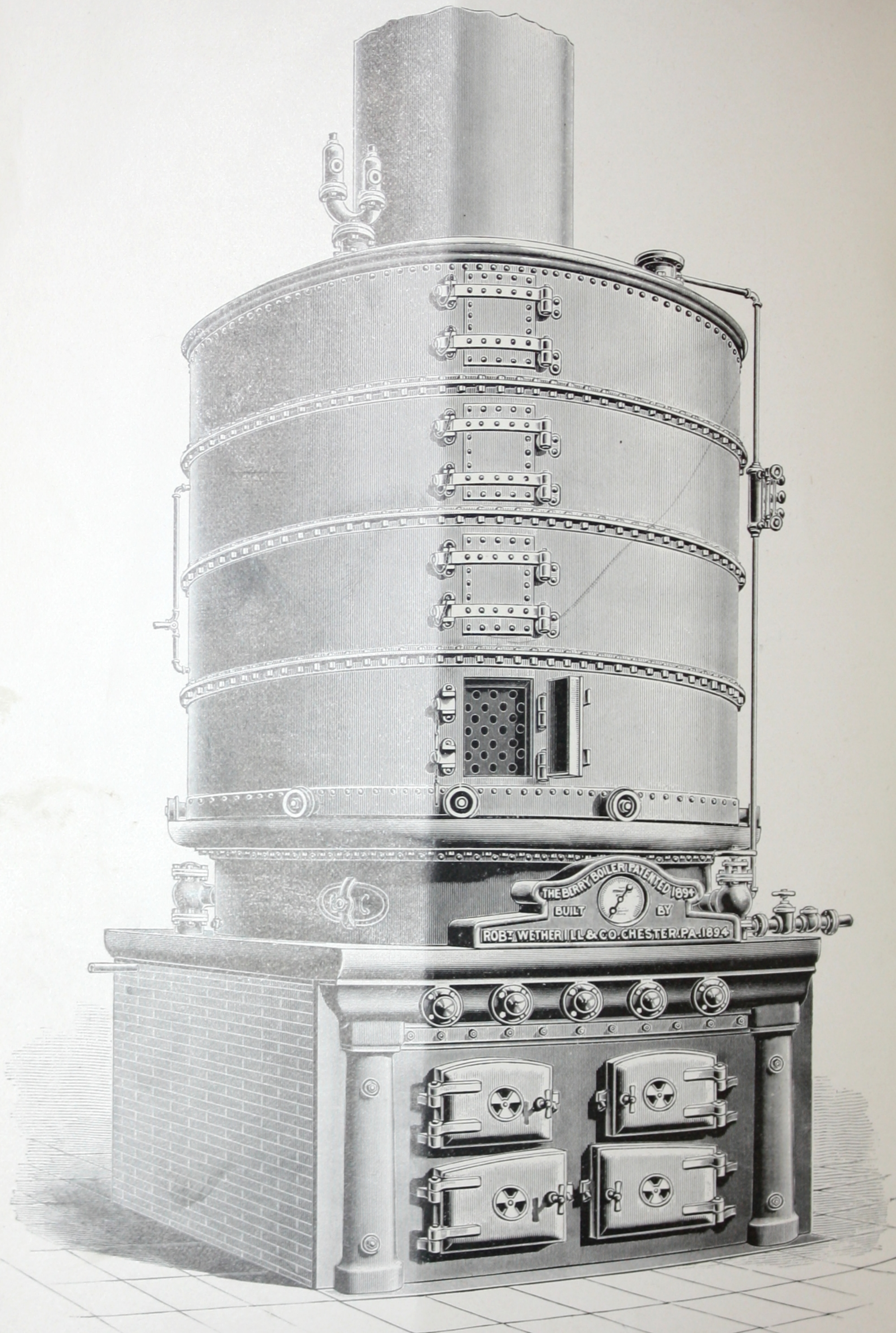
WHICH WE GUARANTEE.

CLAIMS.

We claim to have embodied in this construction all the good points of the numerous modern boilers and to have eliminated all their objectionable features, while in our patented revoluble casing and flue cleaner we have made a decided step in advance of anything ever before attempted, and show the highest degree of excellence in—

Economy of space occupied.
Economy of material.
Economy of first cost.
Economy of maintenance.
Economy of operating service.
Economy of fuel.
Convenience, durability and safety.

It is as safe as human skill and foresight can make a boiler, and while it *steams quickly*, it will allow of a wider range of neglect than any of its competitors.



250 H. P. Berry Safety Boiler.

Points of Excellence.

First.—The economy of space occupied which, owing to the great concentration of the heating surfaces, their high efficiency and the upright design, is very small—one square foot of floor space per horse-power allows ample room for boiler and firing room.

Second.—Economy in cost of maintenance and operating service.

Third.—The convenience of cleaning inside and outside surfaces. (*a*) By means of the circulating and purifying coil which is a part of each boiler and which effectually prevents the deposit of scale or sediment upon the heating surfaces, and (*b*) the revoluble casing and flue cleaner which keeps the fire surfaces always clean.

Fourth.—Perfectly dry or superheated steam is uniformly furnished.

Fifth.—Simplicity and economy in first cost of installation. No purifiers or separators or other expensive accessories are needed with this boiler.

Sixth.—The minimum of weight combined with ample steam and water spaces. The design is admirable for marine service.

Seventh.—The highest degree of safety and durability, due to the character of materials used (all steel); the enormous strength of the structure, entire freedom from the destructive strains of unequal expansion; the wide range of the water line above the danger point; the "sectional construction" of the circulating coil over the fire; the perfect circulation of the water in the boiler, and the entire freedom from scale or sediment on the heating surfaces.

Eighth.—The highest economy of fuel, resulting from "perfect combustion" in a convenient and roomy furnace, ample draught area, close contact and slow movement of gases over the heating surfaces, large ratio of heating surface to grate surface, perfect insulation, perfect circulation of water, and uniformly clean surfaces inside and out.

Large area through the tubes and upward draught requires a much smaller smokestack to obtain requisite power compared with other boilers.

THE
BERRY BOILER

COMBINES THE

SIMPLICITY AND DURABILITY

OF THE

HORIZONTAL RETURN TUBULAR

WITH THE

SAFETY AND ECONOMY

OF THE

INTERNALLY FIRED MARINE TUBULAR BOILER

AND

Economizes Space, Material and First Cost
to a greater degree than any
Boiler ever devised.

We build these Boilers in units ranging from 100 to 350 horse-power each, and vary the relative height and diameter to suit conditions as we find them. We will be pleased to send an expert (at our expense) to examine old or proposed new Power Plants, with a view to submitting proposals for new, or changes in existing plants. In many cases we will be able to more than double the capacity of a Boiler Plant by substituting New for Old Boilers *in the same space.*

Description.

The boiler consists of two vertical cylindrical shells, united at the top by a crowned ring and at the bottom by a conical crown sheet. These rings do not require bracing and accommodate any difference in expansion that may occur. Tubes radiate from the inner to the outer shell, uniting and bracing them and forming a structure of great strength.

A deflecting arch of fire brick is placed in the internal flue at a point above about two-thirds of the submerged tubes, and a casing or smoke flue surrounds the boiler on the outside.

The boiler is supported on the permanent side walls of the furnace which is square, and lined throughout with an independent fire-brick lining. A continuous coil of four-inch tubes is made to support the covering tile which protect the outer portion of the boiler from the fire.

The gases rise into the internal combustion chamber, are deflected by the arch and pass through the tubes to the outside flue, then upward and inward through the upper section of tubes to the internal flue, and thence to the stack.

The circulation of the water in the boiler is easy and natural, up the inside and down the outside. One-half the area is maintained for circulation on the inside flue sheet and three-quarters on the outside sheet.

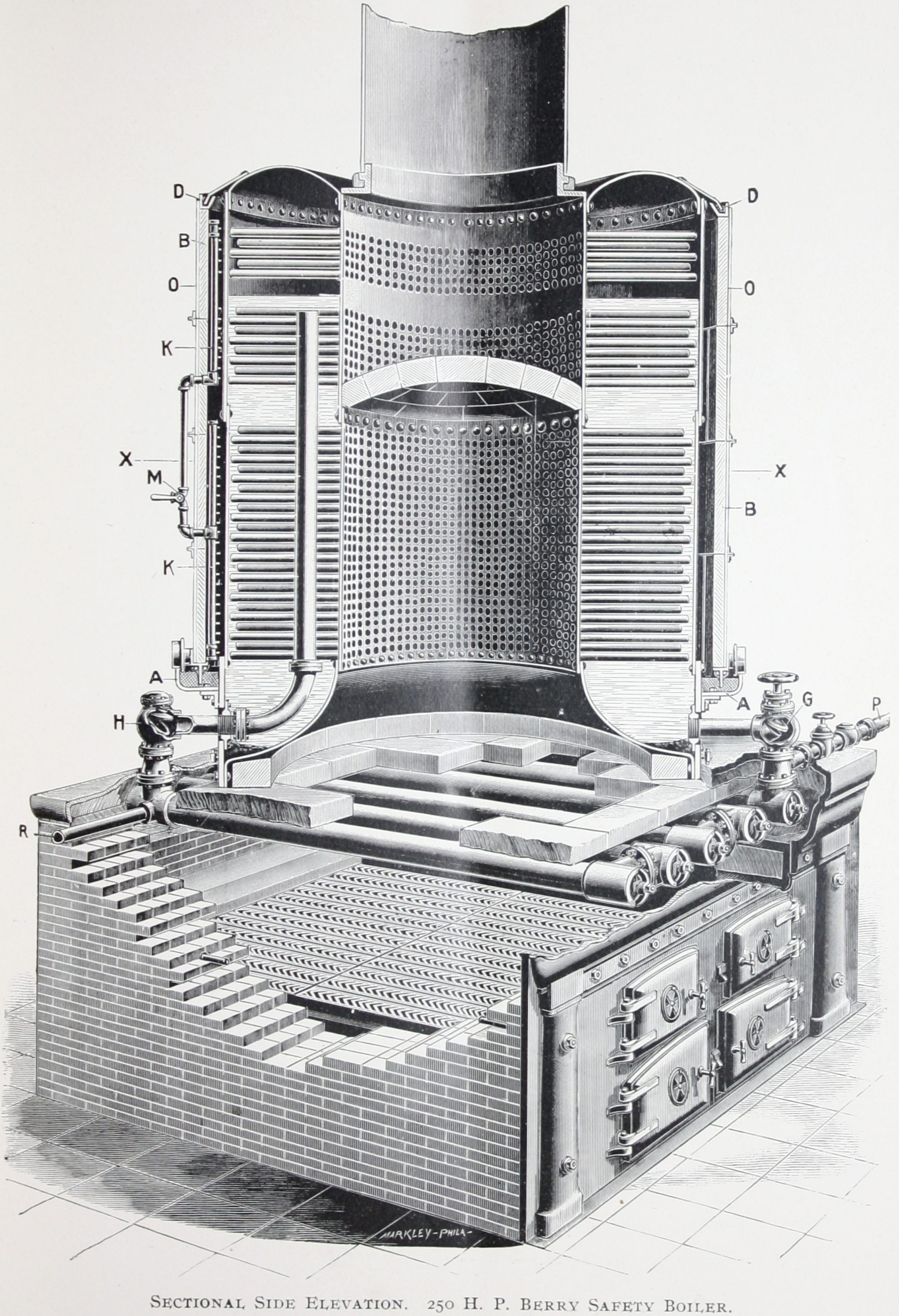
The circulation in the coil is as follows: One end of the coil is connected to the outside shell of the boiler through a check valve "G" opening outward. At this end the feed pipe is also connected outside the check. The coil extends back and forth under the boiler, over the fire, and at the other end is connected to a check valve opening inward to a stand pipe which rises near the inner shell to the water line.

As soon as the water is heated in the coil it rises in the stand pipe and gives the conditions for circulation immediately, viz.: A warm column against a cooler column of water. When the boiler is steaming rapidly the progress of the globules of steam through the stand pipe gives rise to a circulation of great rapidity; an indicator in the coil has shown a speed of 100 to 150 feet per minute.

The feed water is introduced into this stream and mingles with many times its volume of water which has the temperature of the stream, and since it must pass through all the pipes in the coil, it reaches the boiler at a temperature above the point of precipitation and is carried with whatever of sediment may be in it (the speed of the current prevents the deposit in the coil), up, past all the highly heated surfaces to the water line, where it is liberated and makes its first passage in the boiler with the slowly descending current around the outside shell affording the opportunity to deposit the sediment in the outside corner where the fire does not reach and where blow cocks are provided for blowing it off. A man-hole is provided for entering this space, which is entirely unobstructed and may be easily cleaned. By this arrangement each boiler is its own purifier and the tubes and crown sheet are kept perfectly clean and free from scale. Hand-holes are also provided in the steel headers at each end of the tubes in the coil for cleaning or repairs, and the coil, or any part of it, may be removed without trouble.

The casing or smoke jacket is lined with non-conducting material and is mounted upon wheels which run upon a track secured to the boiler. The top and bottom joints are made by a sand pocket so that the casing may be easily revolved. A door is provided from top to bottom, which, by revolving the casing, may be brought opposite any part of the boiler for inspection, cleaning, cr repairs. Secured to the inside of this casing is a blast pipe which has a nozzle opposite each tube in a vertical row. By means of a flexible pipe a steam connection is made, and by revolving the casing all the tubes may be blown perfectly clean while the boiler is in full service. The fact that the tubes are short and of small diameter, and that the blowing is done with closed doors and hot fires, thus preventing condensation, contributes to the perfection of this operation. It requires a very few minutes to blow all the tubes in a 250 horse-power boiler entirely without discomfort to the operator.

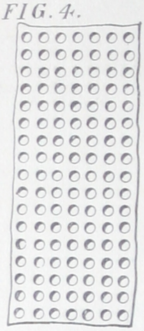
The combined area of the tubes in the first or outward passage is 25 per cent. of the grate surface, and in the second is reduced to 15 per cent., thus allowing ample flue area while the gases are highly heated and expanded, the result of which is perfect combustion from quick draught and a slow movement of the gases over the initial surfaces. The small diameter of tubes insures at the same time a close contact of gases, and to these conditions the phenomenal performance of the boiler is due.



Sectional Side Elevation. 250 H. P. Berry Safety Boiler.

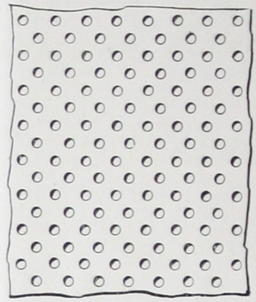
DEVELOPMENT OF FLUE SHEETS.

FIG. 4.



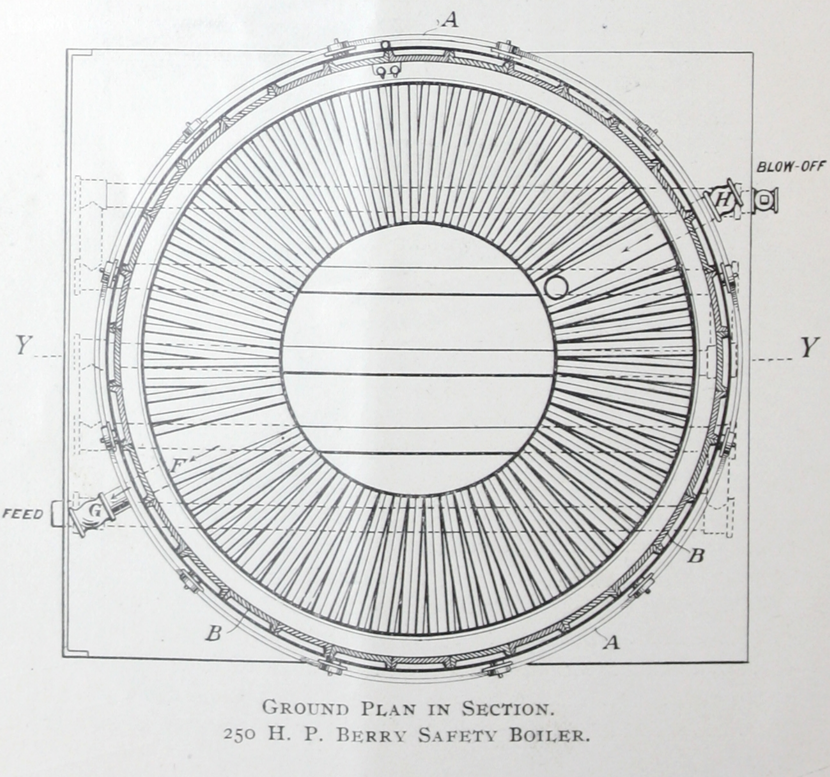
INSIDE SHEET.

FIG. 5



OUTSIDE SHEET.

FIG. 3.
Section on line XX.



GROUND PLAN IN SECTION.
250 H. P. BERRY SAFETY BOILER.

The Berry Safety Boiler.

In what follows we undertake to prove theoretically that our claims are just; but to those who are not familiar with the theories of steam generation, or have not the time or disposition to investigate the matter, we offer the fullest guarantees of all we claim as a basis of all contracts.

The conditions that control the efficiency of a steam boiler are as follows:

THE FURNACE,

which must be convenient, roomy, and so arranged that a sufficiently high temperature may be attained in it to insure perfect combustion of fuel, without the admission of too much air. No possible arrangement of heating surfaces, however skilful or cunning, can remedy the evils of a faulty furnace.

In the Berry boiler the greatest simplicity in the form of the furnace is maintained, affording the best possible opportunity to get the coal in and the ashes out by hand, and the fact that it is lined throughout with fire brick, and has a large combustion chamber with ample draught area, insures the nearest possible approach to perfect combustion of fuel. Our guarantees are made on the basis of a plain, well-constructed stationary grate, with hand firing, but any of the rocking or automatic grates are easily applied, if desired.

THE RATIO OF HEATING SURFACE TO GRATE SURFACE.

No degree of perfection in combustion of fuel will result in ultimate economy unless an ample area of heating surface is presented to the products of combustion to absorb their heat before they pass to the chimney. This ratio varies from 20 to 75 in different types of boiler, but the result of numerous experiments and years of experience indicate that with a combustion of twenty-five pounds of coal per hour per square foot of grate, a ratio of 35 is ample. As the rate of combustion increases a larger ratio is needed, rising sometimes to 90 or 100 in locomotive boilers when fifty or sixty pounds of coal are consumed per square foot of grate per hour. In the Berry boiler we are able to adjust these proportions precisely, never, however, allowing the ratio to fall below

30. In the boiler herewith illustrated, in which it is intended to burn a maximum of twenty-two pounds of coal per square foot of grate per hour, the ratio is 36 of submerged heating surface to 1 of grate ; to this is added seven feet of superheating surface, making forty-three in all.

THE CHARACTER OF THE HEATING SURFACES

and their disposition with reference to the fire and the water, will greatly affect their efficiency. It is quite possible to have a perfect fire and an ample proportion of heating surface, and still have a very inefficient boiler. As to the plates themselves, it need only be said that they should be as thin as possible consistent with the necessary strength, and that they should be clean ; a coating of dirt or soot on the fire side, or of scale on the water side of the plates, will greatly reduce their capacity to transmit heat. We attach great importance to this fact, and claim for the Berry boiler that the surfaces, consisting of plain plates three-eighths inch thick, and of fire tubes one-tenth inch thick, so arranged that they can be kept reasonably clean, meet both these requirements, and are therefore in the highest degree effective.

Just here we join issue squarely with the advocates of water tubes and insist that while the water tube has the merit of being strong and thin, yet, as it is ordinarily applied, the difficulty of keeping it clean on the inside renders it unsatisfactory for heating surfaces, where there are impurities in the water, and this is the case 99 times out of 100.

SCALE.

Experience has shown that the scale that collects on the outside of a fire tube will crack and shell off from time to time, as the tube expands and contracts with varying temperatures, and leave the surface comparatively clean, whereas with water tubes this cannot occur ; the scale, being enclosed in the tube, cannot fall away if loosened, and it continually increases in thickness while the tube decreases in efficiency and finally burns out.

It is a common experience to find four-inch water tubes with one to one and one-half inch of scale in them, and since it costs more to clean them than new tubes are worth, the usual practice is to renew them. Instances may be cited where it is necessary to renew the lower sections of water-tube boilers once and some-

times twice each year. While, on the contrary, horizontal fire tubes are found to continue comparatively clean for years, thus retaining their efficiency and costing nothing for repairs.

THE PRECIPITATION OF SCALE

is a source of trouble in the ordinary horizontal cylindrical tubular boiler, and of positive danger in vertical tubular boilers, since it is most likely to occur immediately after the boiler has been cleaned, and while it is being refilled with water, the change of temperature loosens the scale and it falls to the bottom, and frequently the first fire after cleaning the boiler burns out the crown sheet. In an experience of twenty years we have noticed that in more than half the cases of overheated crown sheets that have come under our notice, the damage was done on Monday morning, the boiler having been cold over Sunday, and in most cases having been opened and cleaned. The crown sheet of this boiler is especially designed to avoid this difficulty, it slopes abruptly from the centre to the outside and away from the fire, where the sediment may lie on sheets entirely protected from the fire, and where openings are provided for its removal.

TRANSMISSION OF HEAT.

We claim further that the water tube, if it could be kept clean, is not as good as the fire tube for heating surface, for the reason that iron conducts the heat from the fire much more rapidly than the water will absorb it from the iron, the relative conducting power of iron and water is 5 to 1, so that, theoretically, the surface presented to the fire should be much less than that presented to the water; with a fire tube this is the case, and the smaller in diameter the tube is the more perfectly it meets this condition, while the water tube reverses the condition and presents more surface to the fire than to the water.

This principle is perfectly illustrated in the fire box sheets in a locomotive boiler which have numerous stays projecting into the water, thus enabling them to distribute the intense heat without injury.

EXTERNAL CLEANLINESS.

But it is also true, though of less importance, that the fire surfaces should be kept clean, and when fire tubes of great length and small diameter are used, this is sometimes difficult if not impossible.

In the Berry boiler the tubes are short, and provision is made by means of the revolving casing and blast nozzles, for blowing the dust out of the tubes frequently while the boiler is in full service, and also for scraping them by hand when the boiler is idle, and thus they may be kept clean inside.

INTERNAL CLEANLINESS.

By the use of our patented circulation coil and feed water purifier, which is part of each boiler, we are able so to handle the sediment in the worst kinds of water as to entirely prevent its accumulation upon the highly heated surfaces. No feed water purifiers or other expensive accessories are needed with this boiler. Our guarantees are made upon the basis of *continued efficiency* with all kinds of water for a period of five years.

THE DIAMETER OF A FIRE TUBE

is an important consideration also. The rapidity of the exchange of heat between two bodies varies as the square of the distance they are apart, and also as the difference in temperature, for example, the gases in a two-inch tube are nowhere more than one inch from the surface, while in a four-inch tube they are twice that distance, so that the exchange from the centre of the tube is four times as rapid in the two-inch tube as it is in the four-inch tube. We have made numerous experiments to arrive at the correct diameters for tubes under varying circumstances and discover that the smaller the tube, *providing it can be kept clean*, the more efficient it is per square foot of surface. We find also that allowing twice as much space between the tubes for the circulation of the water, it is still possible to get 50 per cent. more heating surface in one cubic foot of space with two-inch tubes than with four-inch. A good illustration of this fact is found in the surface condensers, in which by the use of an immense number of small tubes we are able in a comparatively small space to instantly condense the steam from our largest engines. The largest tube we use in the Berry boiler is two inches outside diameter.

DRAUGHT AREA.

By the use of a large number of short tubes of small diameter we are able to secure a large draught area and consequent slow movement of gases, thus insuring perfect combustion of fuel while the

CLOSE CONTACT

of the highly heated gases with the heating surfaces is assured. These conditions and proportions are more perfectly adjusted in the Berry boiler than in any other on the market.

THE DISPOSITION OR LOCATION

of the surfaces with reference to the fire is a matter of prime importance. The experiments of M. Paul Hevrer, in 1874, gave some remarkable results, and as they bear directly upon this point we give them in full. M. Hevrer used an ordinary locomotive boiler, consisting of a rectangular fire box and tubes projecting from it into a cylindrical extension for a distance of twelve feet and three inches. He introduced four partitions into the cylindrical or tube portion of the boiler the first three inches from the flue sheet, and the others three feet apart, dividing the boiler into five compartments. He then supplied each compartment with separate feed pipe, so as to note the amount of water evaporated in each, and noted the following results:

	Fire box and three inches of tubes.	Three feet of tubes.	Three feet of tubes.	Three feet of tubes.	Three feet of tubes.
Square feet of surface .	76·43	179·	179·	179·	179·
Pounds of water evaporated per square foot of surface per hour . . .	24·5	8·72	4·42	2·52	1·68
Total evaporation in pounds per hour . . .	1871·5	1560·8	791·	451.	290·

Average 6·2 pounds per square foot of surface per hour.

From this it appears that the initial surfaces, or those upon which the gases impinge before they have lost any of their heat, evaporated nearly forty per cent. of all the water, while the succeeding surfaces show a constantly decreasing duty, due to the decreasing difference in temperatures. Had M. Hevrer provided a smaller fire box, still retaining the same aggregate of surface by using longer tubes and fewer in number, the average duty must have fallen below 6·2 pounds, while on the contrary had he enlarged the fire box and increased the number of his tubes and made them shorter to keep the surface as before, he would have

increased the average duty of the surfaces. In M. Hevrer's experiment ten per cent. of the surfaces were initial. In the Berry boiler from twenty to twenty-five per cent. of the surfaces are initial, and the average duty of the submerged surfaces is above five pounds. This is a higher duty than any other boiler on the market is capable of for dry steam with natural draught.

But it is not enough that the surfaces are well arranged with respect to the fire. They must also be so situated in the water that all parts of the body of water in the boiler may become evenly heated, and that a *perfect circulation* of the water may occur. We claim that in the Berry boiler the highest degree of perfection is attained in this respect. The heat is distributed to every part of the boiler alike by the tubes radiating in every direction, and the conditions of perfect circulation are met, in that the annular column of water which surrounds the fire is more heated in the centre than on the outside and that the circulation is easy and natural up the centre and down the outside. The performance of the Berry boiler, in this respect, is simply marvellous. The heating surfaces are very much concentrated and are very large in proportion to the volume of water, yet there is not the slightest indication of foaming under the most intense firing. Indicators placed in the ascending and descending streams show steady circulation at a speed incredible, unless the principles involved are understood.

THE CIRCULATION OF WATER

depends primarily upon uneven heating. That portion which is most heated expands and becomes lighter than the rest and rises, while the cooler water sinks, but since there can be but a slight difference in temperature, the difference in the weight of the column is so slight that many are unable to account for the rapid movement that is claimed.

If we consider the water at a temperature below the boiling point (say at 200° F.) then the increase of 1° in one portion over another will cause a circulation, but it will be very slight, indeed, scarcely perceptible, because there is not difference enough in weight to cause it, but if we consider that the water in a boiler is *always at the boiling point*, and that the water farthest from the fire will be slightly below that point, and consequently of full specific gravity, and that the water nearest the fire will be at, or slightly above, boiling point, and consequently full of globules of steam, which are many times as light as an equal volume of

water, we can understand how a difference of one-half of 1° in temperature may make a difference of four or five to one in the weight of the respective columns, but the simple presence of these lighter globules in the column, and the consequent reduction of its total weight, is not sufficient to account for the rapid movement observed, for the pressure *per square inch* is not reduced thereby; but *the progress of these globules through the surrounding water*, which, owing to their lightness, is very rapid, gives rise to a movement of the water itself which is scarcely less rapid than that of the steam, and thus the observed current of twenty-five to seventy-five feet per minute is easily accounted for.

The true philosophy of this phenomenon is the same as that of the old-fashioned chain pump, in which the enlarged links or "buckets" on the moving chain represent the globules of steam rising in the heated column, and by frictional contact causing the column to move also.

DRY STEAM.

The conditions requisite for making dry steam are as follows:

(1) That a liberal area of surface be provided where the steam may escape from the water.

(2) That liberal steam room be provided.

(3) That the steam be taken from the boiler at a sufficient distance above the water.

(4) That the steam impinge upon more or less of moderately heated surface in its passage from the boiler.

All these conditions are met in the Berry boiler. In the boiler illustrated the evaporating surface is 48 square feet; steam space, 110 cubic feet, and the liberal superheating surfaces insure not only dry steam, but a moderate degree of superheating.

The loss of heat from radiation is also reduced to a minimum, since the entire boiler is enveloped by the gases after they have passed through the tubes, and the outside casing is lined with an incombustible non-conductor to complete the insulation, and the least possible loss from radiation is experienced.

ECONOMY OF FUEL.

Having shown that in every known requirement for a high degree of efficiency, the Berry boiler is up to or above the highest standards, the inference may be drawn that not only a high duty, but a high degree of economy must necessarily follow. We

guarantee to evaporate 10·5 pounds of water from and at 212° into absolutely dry steam per pound of combustible, not only during the first week of service, but as a constant duty through a series of years.

FIRST COST.

The Berry boiler is not a "cheap" boiler, nor do we propose to enter into competition with makers of "cheap" boilers; on the contrary, our study has been to make the best boiler we possibly could, using the best materials, the best tools and the best workmen we could find, regardless of expense, and we welcome the manifest disposition on the part of inspectors and engineers generally, to raise the standards of excellence in view of the higher duties required at this time. That our boiler costs less than other first-class boilers is due to the following facts:

(1) There is no waste material in or about the boiler, almost the entire surface is exposed both to the fire and to the water. It is a remarkable fact that in the boiler illustrated, which is built to carry 150 pounds pressure, the total weight per square foot of heating surface is but nine and and one-half pounds, and while nothing has been spared to make the boiler convenient, easy of access and durable, a minimum of material is used in the accessories. The total weight of material (exclusive of brick) in the entire boiler and furnace is but fourteen pounds per square foot of heating surface.

(2) The high average efficiency of the heating surfaces reduces the cost per horse-power. We guarantee a maximum evaporation of five pounds of water per square foot of surface or one horse-power to six and one-half square feet of surface, as against ten to fifteen in other boilers.

(3) The simplicity of the setting. The boiler being complete when it leaves the shop, the cost of erection is comparatively small and the cost of brick-work insignificant.

THE ECONOMY OF SPACE OCCUPIED.

(4) House room costs money, and frequently the question of room is one of the most serious the engineer has to consider, and a considerable proportion of the cost of a boiler plant is in the building. This boiler occupies but one square foot of floor space per horse-power, in fact we can install from two to five times the power on the same floor space as compared with other boilers; we guarantee twice the power in the same total space occupied.

No definite statement of the total cost per horse-power of a boiler plant can be given unless all the conditions of the case are known.

We prefer to give estimates for the entire plant, based upon the observations of our own engineers, and will do so on application, but since we are able to deliver the boiler f. o. b. for less money per horse-power, and that it will cost less for ground on which to set it, less for foundations and brick-work, less to erect it and less to house it after it is erected, we defy competition in the matter of price.

This matter of economy of space is of utmost importance to electric light and power plants, which need to be centrally located in large cities, and also to many industrial establishments, whose business has outgrown their boiler capacity. In many cases, we are able to substitute the Berry boiler for the old boilers in the same building, and sufficiently increase the power to avoid the necessity and expense of new buildings, and in some cases to actually reduce the consumption of coal so much as to pay the cost of substitution in a short time. For use in large office buildings for heating and lighting, or for any other purpose for which boilers are used, the Berry boiler is without a rival.

SAFETY AND DURABILITY.

Though not exactly synonymous terms, the conditions which contribute to the safety and durability of a boiler are the same and are as follows:

(1) Suitable materials. The Berry boiler is made entirely of steel plates and tubes, no cast iron or other treacherous material is used to stand the strains of pressure, heat and unequal expansion.

(2) The materials should be so disposed as to best resist the strains that come upon them. In this boiler every ounce of metal contributes to the strength of the boiler, and is either in direct tension or compression, and at its very best.

(3) The heat should be so applied that all parts of the boiler will be expanded as near alike as possible, and such unequal expansion as cannot be avoided should have opportunity to expend itself without violence to other parts. The strains due to unequal expansion are often much greater than those due to pressure, and often cause disaster. This is true of all externally fired boilers, and in all others where the circulation is not perfect. In the Berry boiler the heat is evenly distributed from an internal furnace and the difference in temperature is imperceptible.

(4) The circulation of the water should be even and regular, and the surfaces exposed to the fire kept free from sediment. As has already been shown, this boiler meets these conditions perfectly, while every seam may be thoroughly inspected internally and externally, without disturbing anything, and ample room is provided for a man to inspect and clean the crown sheet when necessary.

WATER LEVEL.

(5) No boiler is safe unless kept supplied with water, but in the Berry boiler the water may vary from two to three feet in height without danger, and this variation represents more than an hour's run at full duty. The fact that the tubes, which radiate in every direction and are spread apart in the outside shell so as not to reduce its strength below that of the seam, act as braces, while at the same time they reduce the pressure by the amount of area removed (the distinctive features of this construction), enables us to build to carry any desired pressure with the highest factor of safety, so that for all practical purposes the strength and durability of our boilers is beyond question.

For Further Particulars, address

Robert Wetherill & Co.

CHESTER, PENNA.

BERRY BOILER

CARRIES

HIGH PRESSURE

AND FURNISHES

SAFE STEAM

QUICK STEAM

DRY STEAM

CHEAP STEAM

ROBERT WETHERILL & CO.

CHESTER, PENNA.